August 13, 2004

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U.S. Department of Energy
National Energy Technology Laboratory
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Pittsburgh, PA 15236-0940

Dear AAD Document Control:

Subject: Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems
DOE NETL Cooperative Agreement No. DE-FC26-03NT41989
UND Funds 4268, 4269, 4271, and 4272

Enclosed are a hard copy and one electronic copy in Adobe Acrobat file format of the April 1 – June 30, 2004, Quarterly Status Report for the project entitled "Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems." Also enclosed are the hard copy and the Adobe Acrobat version of the required PowerPoint document for the subject agreement. The Request for Patent Clearance for Release of Contracted Research Documents is also enclosed.

If you have any questions, please call me at (701) 777-5276, fax at (701) 777-5181, or e-mail at mholmes@undeerc.org.

Sincerely,

Michael J. Holmes
Senior Research Advisor

MJH/krg

Enclosures

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Jeff Thompson, EERC
Michelle Olderbak, EERC

ENHANCING CARBON REACTIVITY IN MERCURY CONTROL IN LIGNITE-FIRED SYSTEMS

Technical Progress Report

For the period April 1–June 30, 2004

Prepared for:

AAD Document Control

U.S. Department of Energy
National Energy Technology Laboratory
PO Box 10940, MS 921-107
Pittsburgh, PA 15236-0940

DOE NETL Cooperative Agreement DE-FC26-03NT41989
UND Funds 4268, 4269, 4271, and 4272
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ENHANCING CARBON REACTIVITY IN MERCURY CONTROL IN LIGNITE-FIRED SYSTEMS

ABSTRACT

This project was awarded under U.S. Department of Energy (DOE) National Energy Technology Laboratory Program Solicitation DE-PS26-03NT41718-01. The Energy & Environmental Research Center (EERC) is leading a consortium-based effort to resolve mercury (Hg) control issues facing the lignite industry. The EERC team, including EPRI, URS Corporation, Babcock & Wilcox, ADA-ES, Apogee, Basin Electric Power Cooperative, Otter Tail Power Company, Great River Energy, Texas Utilities, Montana–Dakota Utilities, Minnkota Power, BNI Coal Ltd., Dakota Westmoreland Corporation, the North American Coal Corporation, and the North Dakota Industrial Commission, seeks to substantially enhance the capability of carbon sorbents to remove Hg from lignite combustion gases to achieve a high level of cost-effective control. The results of this effort will be applicable to virtually all utilities burning lignite in the United States and Canada and will also apply to subbituminous coals. The enhancement processes have been proven at the pilot scale and in limited full-scale tests. Additional optimization testing is continuing on these enhancements, and this project focuses on full-scale testing at four lignite-fired units: Leland Olds Station Unit 1 near Stanton, North Dakota (ND); Stanton Station Units 1 and 10 near Stanton, North Dakota; and Antelope Valley Station Unit 1 near Beulah, North Dakota.

The lignite industry has been proactive in advancing the understanding of control mechanisms and the identification of control options for Hg in lignite combustion flue gases. Over 2 years ago, the EERC and EPRI initiated a series of discussions on Hg control with utilities that burn Fort Union (North Dakota and Saskatchewan) and Texas Basin lignites, representing most of the lignites used in North America. This project is a cooperative effort of these industry partners to address the specific needs and challenges to be met in controlling Hg from lignite-fired power plants.

This project is one of three being conducted by the consortium under the DOE mercury program to systematically test Hg control technologies available for utilities burning lignite. The overall objective of the three projects is to field-test and verify options that can be applied cost-effectively by the lignite industry to reduce Hg emissions. Under this project, the EERC and other team members will test sorbent injection technologies for plants equipped with electrostatic precipitators (ESPs) only and those equipped with spray dryer absorbers combined with fabric filters (SDAs–FFs). The other two projects will test two different oxidation technologies developed to promote Hg capture in systems equipped with an ESP followed by wet flue gas desulfurization. Taken together, the three efforts provide a systematic approach to evaluating control technologies that will help maintain the viability of lignite-fired energy production by providing utilities with lower-cost options for meeting future Hg regulations. This work will be performed with a focus on technology commercialization through industry involvement and by emphasizing communication of results to vendors and utilities throughout the project.

Currently, carbon injection technologies have been shown to be the most viable commercial options for systems without SO_2 scrubbers, including those emitting high levels of elemental mercury (Hg^0). Lignites, because of their low chlorine and high calcium contents, produce high levels of Hg^0 and have also shown low Hg–sorbent reactivity. Two technologies have been identified that overcome these problems by using either 1) furnace additives or 2) treated carbons to significantly increase sorbent reactivity and resultant capture of Hg. Both technologies have been successfully demonstrated in pilot-scale and short-term field tests and are ready for large-scale testing and verification. Each will be tested on both a unit configured with an ESP only and one equipped with an SDA–FF combination.

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LIST OF ABBREVIATIONS

ACI	activated carbon injection
APCD	air pollution control device
AVS1	Antelope Valley Station Unit 1
BEPC	Basin Electric Power Cooperative
BH	baghouse
B&W	Babcock & Wilcox
CMM	continuous mercury monitor
DOE	U.S. Department of Energy
EERC	Energy & Environmental Research Center
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
FBC	fluidized-bed combustion
FF	fabric filter
FGD	flue gas desulfurization
GRE	Great River Energy
IAC	iodine-impregnated activated carbon
ICR	Information Collection Request (EPA's)
LAC	lignite-based activated carbon
LNB	low-NO_x burner
LOS1	Leland Olds Station Unit 1
NDIC	North Dakota Industrial Commission
NETL	National Energy Technology Laboratory
OFA	overfire air
OH	Ontario Hydro
P4	We Energies' Power Plant
PAC	powdered activated carbon
PRB	Powder River Basin
SCA	specific collection area
SD	spray dryer
SDA	spray dryer absorber
SEA	sorbent enhancement additive
SS1	Stanton Station Unit 1
SS10	Stanton Station Unit 10

ENHANCING CARBON REACTIVITY IN MERCURY CONTROL IN LIGNITE-FIRED SYSTEMS

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) is conducting a consortium-based effort to resolve mercury (Hg) control issues facing the lignite industry in this U.S. Department of Energy (DOE)-funded project. The EERC team, including EPRI, URS Corporation, Babcock & Wilcox (B&W), ADA-ES, Apogee, Basin Electric Power Cooperative, Otter Tail Power Company, Great River Energy, Texas Utilities, Montana–Dakota Utilities, Minnkota Power, Saskatchewan Power, BNI Coal Ltd., Dakota Westmoreland Corporation, North American Coal Corporation, and the North Dakota Industrial Commission, seeks to substantially enhance the capability of carbon sorbents to remove Hg from lignite combustion gases to achieve a high level of cost-effective control. The results of this effort will be applicable to virtually all utilities burning lignite in the United States and Canada and will also apply to subbituminous coals. The enhancement processes have been proven at the pilot scale and in limited full-scale tests. Additional optimization testing is continuing on these enhancements, and this project focuses on full-scale testing at four lignite-fired units: Leland Olds Station Unit 1 near Stanton, North Dakota; Stanton Station Units 1 and 10 near Stanton, North Dakota; and Antelope Valley Station Unit 1 near Beulah, North Dakota.

The lignite industry has been proactive in advancing the understanding of control mechanisms and the identification of control options for Hg in lignite combustion flue gases. Over 2 years ago, the EERC and EPRI initiated a series of discussions on Hg control with utilities that burn Fort Union (North Dakota and Saskatchewan) and Texas Basin lignites, representing most of the lignites used in North America. This project is a cooperative effort of these industry partners to address the specific needs and challenges to be met in controlling Hg from lignite-fired power plants.

This project is one of three being conducted by the consortium under the DOE mercury program to systematically test Hg control technologies available for utilities burning lignite. The overall objective of the three projects is to field-test and verify options that can be applied cost-effectively by the lignite industry to reduce Hg emissions. Under this project, the EERC and other team members will test sorbent injection technologies for plants equipped with electrostatic precipitators (ESPs) only and those equipped with spray dryer absorbers combined with fabric filters (SDAs–FFs). The other two projects will test two different oxidation technologies developed to promote Hg capture in systems equipped with an ESP followed by wet flue gas desulfurization. Taken together, the three projects provide a systematic approach to evaluating control technologies that will help maintain the viability of lignite-fired energy production by providing utilities with lower-cost options for meeting future Hg regulations. This work will be performed with a focus on technology commercialization through industry involvement and by emphasizing communication of results to vendors and utilities throughout the project.

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elemental mercury (Hg^0). Lignites, because of their low chlorine and high calcium contents, produce high levels of Hg^0 and have also shown low Hg–sorbent reactivity. Two technologies have been identified that overcome these problems by using either 1) furnace additives or 2) treated carbons to significantly increase sorbent reactivity and resultant capture of Hg. Both technologies have been successfully demonstrated in pilot-scale and short-term field tests and will be tested over a one month period on both a unit configured with an ESP only and one equipped with an SDA–FF combination.

During the current reporting period, testing was completed at Leland Olds Station. Analyses of coal and ash samples from Leland Olds Station were completed. Data reduction has been initiated and is ongoing. In addition, the 1-month test at Stanton Station Unit 10 began. Preliminary results from both of these tests will be presented at the DOE Review Meeting in July. Field testing at Antelope Valley Station is scheduled to occur in the spring of 2005. Work has begun in developing a draft site-specific test plan. Additionally, communication with plant personnel has been ongoing to prepare for the installation of a pad foundation for the carbon injection system.

ENHANCING CARBON REACTIVITY IN MERCURY CONTROL IN LIGNITE-FIRED SYSTEMS

1.0 INTRODUCTION

The Energy & Environmental Research Center (EERC) is conducting a consortium-based effort to resolve mercury (Hg) control issues facing the lignite industry. The EERC team, including EPRI, URS Corporation, Babcock & Wilcox (B&W), ADA-ES, Apogee, Basin Electric Power Cooperative (BEPC), Otter Tail Power Company, Great River Energy (GRE), Texas Utilities, Montana–Dakota Utilities, Minnkota Power, Saskatchewan Power, BNI Coal Ltd., Dakota Westmoreland Corporation, North American Coal Corporation, and the North Dakota Industrial Commission (NDIC), seeks to substantially enhance the capability of carbon sorbents to remove Hg from lignite combustion gases to achieve a high level of cost-effective control. The results of this effort will be applicable to virtually all utilities burning lignite in the United States and Canada and will also apply to subbituminous coals. The enhancement processes have been proven at the pilot scale and in limited full-scale tests. Additional optimization testing is continuing on these enhancements, and this project focuses on full-scale testing at four lignite-fired units: Leland Olds Station Unit 1 (LOS1) near Stanton, North Dakota; Stanton Station Units 1 and 10 (SS1 and SS10) near Stanton, North Dakota; and Antelope Valley Station Unit 1 (AVS1) near Beulah, North Dakota, as listed in Table 1.

Table 1. Description of Test Sites

Plant	Utility Ownership	North Dakota Lignite Mine	Boiler Type	Boiler Size, MW[1]	Particulate Control	SO_2 Control	NO_x Control
LOS1[2]	BEPC	Freedom	Wall fired	220 (110)	ESP/SCA[3]= 320 ft^2/1000 acfm	None	LNB OFA[4]
SS10	GRE	Freedom	Tang. fired	60	FF[5]	Spray dryer	LNB
AVS1	BEPC	Freedom	Tang. fired	440 (220)	FF	Spray dryer	LNB OFA
SS1	GRE	Freedom	Tang. fired	140 (70)	ESP/SCA= 470 ft^2/1000 acfm	None	LNB

[1] Total size of the boiler with the value in parentheses being the test size.
[2] Fires mostly North Dakota lignite; however, periodically fires a 30% blend of Powder River Basin (PRB) coal.
[3] Electrostatic precipitator/specific collection areas.
[4] Low-NO_x burner overfire air.
[5] Fabric filter.

The lignite industry has been proactive in advancing the understanding of control mechanisms and the identification of control options for Hg in lignite combustion flue gases. Over 2 years ago, the EERC and EPRI initiated a series of discussions on Hg control with utilities that burn Fort Union (North Dakota and Saskatchewan) and Texas Basin lignites, representing most of the lignites used in North America. This project is a cooperative effort of these industry partners to address the specific needs and challenges to be met in controlling Hg from lignite-fired power plants.

This project is one of three being conducted by the consortium under the U.S. Department of Energy (DOE) mercury program to systematically test Hg control technologies available for utilities burning lignite. The overall objective of the three efforts is to field-test and verify options that can be applied cost-effectively by the lignite industry to reduce Hg emissions. Under this project, the EERC and other team members will test sorbent injection technologies for plants equipped with ESPs only and those equipped with spray dryer absorbers–fabric filters (SDAs–FFs). The other two projects will test two different oxidation technologies developed to promote Hg capture in systems equipped with an ESP followed by wet flue gas desulfurization (FGD). Taken together, the three projects provide a systematic approach to evaluating control technologies that will help maintain the viability of lignite-fired energy production by providing utilities with lower-cost options for meeting future Hg regulations. This work will be performed with a focus on technology commercialization through industry involvement and by emphasizing communication of results to vendors and utilities throughout the project.

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2.0 BACKGROUND

Mercury is an immediate concern for the U.S. electric power industry because of the U.S. Environmental Protection Agency's (EPA's) December 2000 decision that regulation of mercury from coal-fired electric utility steam-generating units is appropriate and necessary under Section 112 of the Clean Air Act (1). EPA determined that mercury emissions from power plants pose significant hazards to public health and must be reduced. The 1997 EPA Mercury Study Report to Congress (2) and the 1998 Utility Hazardous Air Pollutant Report to Congress (3) both identified coal-fired boilers as the largest single category of atmospheric mercury emissions in the United States, accounting for about one-third of the total anthropogenic emissions. On December 15, 2003, EPA published the proposed utility mercury reductions rule in order to solicit comments on multiple approaches for mercury emission control (4). EPA is currently addressing comments on the proposed rules and is scheduled to promulgate the final rule in March of 2005.

Despite the fact that mercury regulations for coal-fired utilities are imminent, significant issues remain and need to be resolved. DOE's National Energy Technology Laboratory (NETL) has acknowledged that data gaps exist for lignite and PRB (Powder River Basin) coals and blends, which represent almost 50% of the coal fired in the United States. These coals produce gases high in Hg^0, which is difficult to control. Questions still exist regarding the impact of various air pollution control devices (APCDs) and technologies for lignite-fired units. Unanswered questions remain beyond what can be addressed by the Information Collection Request (ICR) data. The lignite-focused consortium believes there is a critical need for 1) large-scale testing of sorbent injection technologies to assess enhanced Hg–sorbent reactivity for lignites and 2) field data that can be used for evaluation of technology performance and economics, the final fate of the captured mercury, and the balance of plant impacts. This project has been developed based on critical input from consortium members to directly address these issues and fill in data gaps for low-rank coals.

In general, lignitic coals are unique because of a highly variable ash content, ash rich in alkali and alkaline-earth elements, high oxygen levels, high moisture levels, and low chlorine content. Lignite coals typically contain comparable levels of Hg but significantly lower levels of chlorine, compared to bituminous coals. Lignites often have chlorine concentrations well below 200 ppm in the coal, whereas bituminous coals often have chlorine levels in excess of 1000 ppm. Lignite coals are also distinguished by much higher calcium contents. These differences in composition have important effects on the form of Hg emitted from a boiler and the capabilities of different control technologies to remove Hg from flue gas. Coals containing chlorine levels greater than 200 ppm (Appalachian and Illinois Basin coals) typically produce Hg in flue gas dominated by more easily removable mercuric compounds (Hg^{2+}), most likely mercuric chloride ($HgCl_2$). Conversely, experimental results indicate that flue gases generated from combustion of low-chlorine (<50 ppm) coal usually contain predominantly Hg^0, which is substantially more difficult to remove than Hg^{2+} (3). Additionally, the high calcium contents of lignite coals may reduce the oxidizing effect of the already low chlorine content by reactively scavenging chlorine species (Cl, HCl, and Cl_2) from the combustion flue gas. The level of chlorine in recently tested lignite coals from North Dakota and Saskatchewan ranged from 11 to 18 ppm in the coal on a dry basis, respectively. These chlorine levels are lower than those previously reported for lignite coals (including ICR results) due in part to recent improvements in methods and instrumentation.

Lignite-fired power plants have shown a limited ability to control Hg emissions in currently installed ESPs, SDAs, and wet FGD systems (5). As stated earlier, this low level of control can be attributed to the high proportions of Hg^0 and low levels of chlorine present in the flue gas. Speciation of Hg in flue gases for lignites analyzed as part of the EPA ICR for Hg data showed that Hg^0 concentration ranged from 56% to 96% and Hg^{2+} ranged from 4% to 44%. The higher levels of Hg^{2+} were only found in a fluidized-bed combustion (FBC) system. Typically, the form of Hg in the pulverized coal- and cyclone-fired units is dominated by Hg^0, >85% of the total. Furthermore, the relatively high Hg content of lignites (on a Btu basis) makes Hg control even more difficult compared to bituminous coals, and the average Hg^0 emitted from lignite-fired power plants is roughly 8.5 lb/TBtu (5–7).

Activated carbon injection is a demonstrated technology for adsorption of both Hg^0 and Hg^{2+} upstream of a particulate control device such as an FF or ESP. The chemical speciation of Hg affects the capture mechanism and ultimate environmental fate (7), but powdered activated carbons (PACs) have the potential to effectively sorb Hg^0 and Hg^{2+}, depending upon the carbon characteristics and flue gas composition (8). Most PAC research has been performed in fixed-bed reactors that simulate relatively long residence time applications (gas–solid contact times of minutes or hours), as would be the case for Hg capture by an FF cake (9). However, because most of the coal-burning boilers in the United States employ ESPs for controlling particulate emissions, technologies are needed that provide short-residence-time (seconds) in-flight capture of Hg^0. The projected annual cost for PAC adsorption of Hg in a duct injection system is significant, yet low in comparison to other technologies. Carbon-to-Hg weight ratios of 3000–18,000 (lb carbon injected/lb Hg in flue gas) have been estimated to achieve 90% Hg removal from a coal combustion flue gas containing 10 $\mu g/Nm^3$ of Hg (10). More efficient carbon-based sorbents are required to reduce the costs.

Recent EERC testing illustrates the effectiveness of sorbents injected upstream of particulate control devices. EERC pilot-scale ESP and TOXECON™ (activated carbon injection [ACI] between an ESP and FF) Hg removal efficiencies for Fort Union lignite coals from Saskatchewan and North Dakota (Poplar River and Freedom coals) flue gases are compared in Figure 1 to DOE test data obtained at full-scale utility boilers, with ACI into a bituminous coal combustion flue gas upstream of a TOXECON™ (pulse-jet FF) and into bituminous and PRB subbituminous coal combustion flue gases upstream of an ESP. As shown, coal type (i.e., composition) is an important parameter that affects the Hg removal efficiency of a control device. The pilot-scale results for lignite show the need for significantly higher ACI rates to achieve the same performance as for tests with eastern bituminous coals using the same configuration. These higher sorbent requirements for lignite-fired units will translate into higher operating and capital costs if this issue is not resolved.

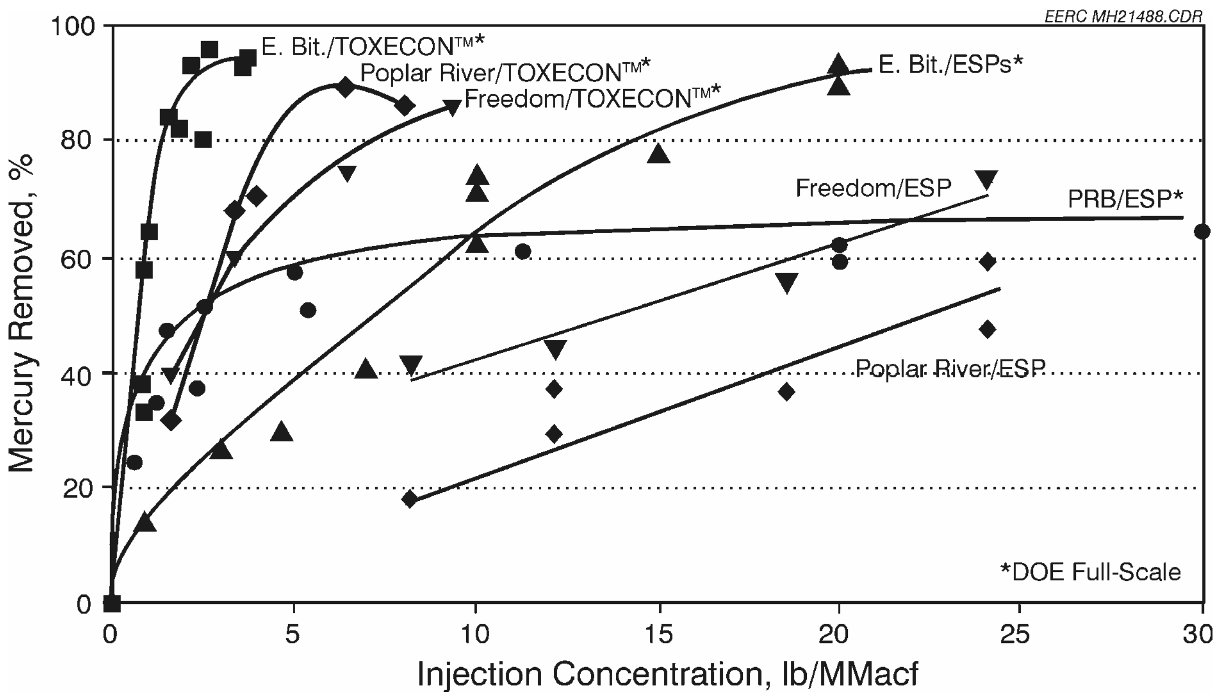

Figure 1. TOXECON™ and ESP Hg removal vs. ACI rate for pilot- (10) and full-scale (11) tests.

EPRI testing at a lignite-fired power plant equipped with an SDA–FF firing Fort Union lignite indicated poor performance of conventional ACI to control Hg. Results from 2002 testing at SS10 suggested two key conclusions: 1) the SDA removed a component from the gas, such as HCl, critical to the effective removal of Hg using ACI and 2) there was a significant effect on Hg removal resulting from sorbent accumulation on the FF between cleaning. Full-scale ACI testing conducted at We Energies' Power Plant (P4), an ESP unit burning a PRB coal, also suggested limited effectiveness of PAC at high injection concentrations because of limited HCl in the gas. It is expected that Hg removal evaluations across the ESP at SS1 will result in similar performance limitations of the untreated PAC material. Sorbents identified as candidates for testing at Stanton were chosen because of their potential to overcome the limitations associated with untreated ACI into units with SDA–FF and ESP configurations.

Researchers at the EERC and elsewhere are striving to attain a better understanding of Hg species reactions on PAC surfaces in order to produce more efficient sorbents. Functional groups containing inorganic elements such as chlorine or sulfur appear to have a significant role in bonding Hg (5). Recently, detailed analysis of sorbents derived from lignites exposed to flue gas and Hg^0 indicated the key species impacting oxidation and retention of Hg on the surface of the carbon contain chlorine and sulfur (5). The chlorine reacts to form organically associated chlorine on the surface, and it appears that the organically associated chlorine on the carbon is the key site responsible for bonding with the Hg^{2+} species.

Sorbent enhancement additives (SEAs) have shown high potential to oxidize Hg^0 for subsequent capture on the sorbent. SEA addition into the coal has been demonstrated at the pilot-scale level by the EERC and EPRI. Recent tests with a North Dakota lignite and very low SEA levels combined with ACI upstream of a TOXECON™ baghouse, an *Advanced Hybrid*™ filter, and an ESP are illustrated in Figure 2. The first part of the figure shows the baseline data for Hg emissions ranging from 9 to 12 $\mu g/Nm^3$, with 80%–90% of the Hg in the elemental form. The second case is ACI with and without the use of SEA, showing a reduction in Hg emissions to 90% removal for the TOXECON™ configuration with SEA. The third case is the *Advanced Hybrid*™ filter, which produced nearly 90% control efficiency with SEA. The final ESP-only case also indicated up to 90% control using SEA, albeit at relatively high injection rates. The control efficiency for the ESP-only case in Figure 2 shows significant potential improvement over past results obtained with the ESP-only illustrated in Figure 1.

This technology also has the potential to improve SDA–FF and wet FGD Hg control efficiency. Additives or oxidants added to the lignite have shown the ability to convert Hg^0 to more reactive oxidized forms, as shown in Figure 3. Recently, short-term testing conducted at Stanton Station indicated the injection of chloride salts resulted in increased Hg^{2+} in the flue gas; up to 70% Hg^{2+} was observed. In addition, the injection of salt resulted in enhanced removal of mercury across the SDA–FF, with removal efficiencies of up to 50% without ACI. Additional testing at this lignite-fired unit also showed that the use of ACI upstream of the SDA–FF system provided significantly better performance when small amounts of SEA were added in the furnace. To summarize, the use of additives upstream of an APCD improved Hg capture both by conversion of the Hg^0 to the more easily removed Hg^{2+} forms and by enhancing the reactivity of Hg^0 with PACs and other sorbents.

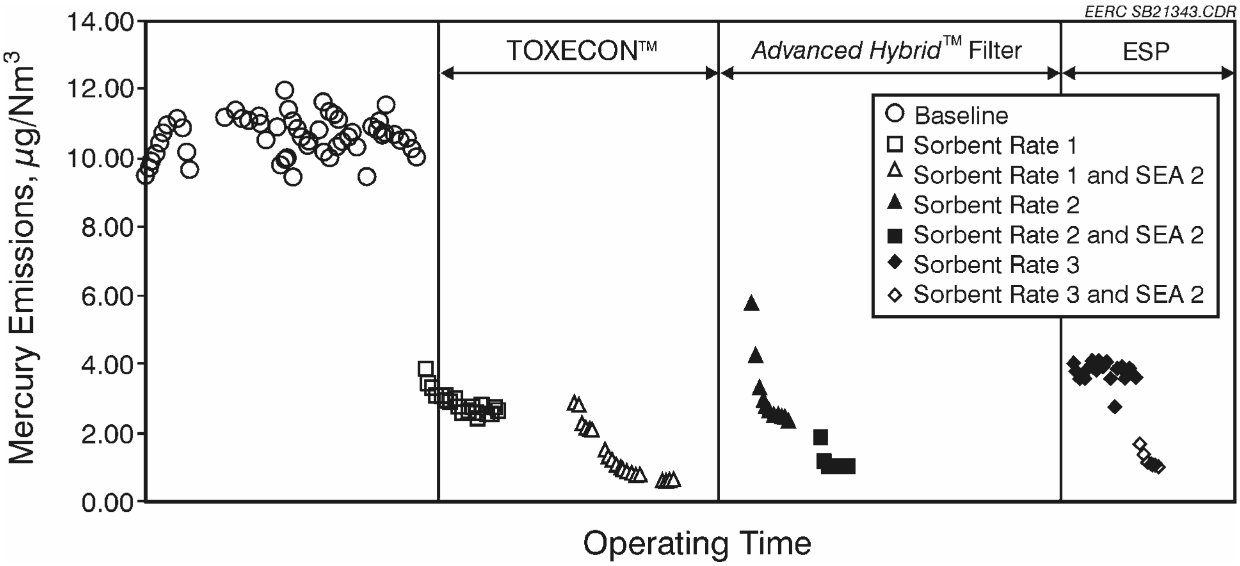

Figure 2. Hg emissions for ACI combined with coal additives.

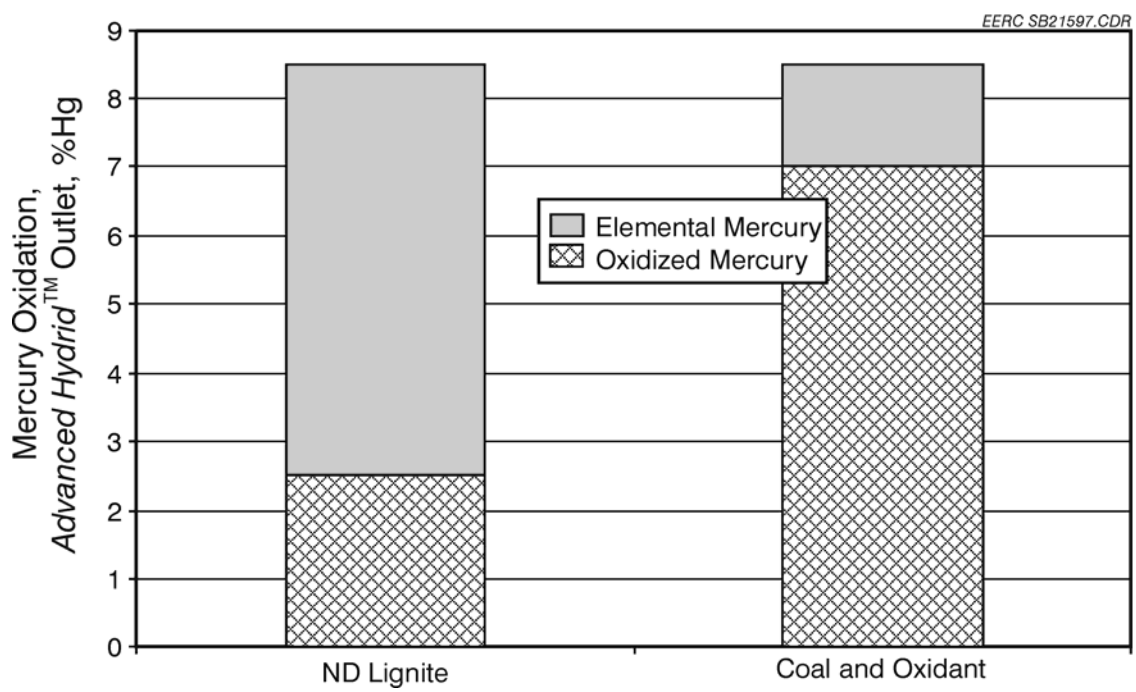

Figure 3. Oxidation of mercury through the addition of a chlorine-containing additive to coal.

The enhanced sorbent injection testing involves the use of sorbents that have been treated prior to injection into the flue gases. Previous EPRI testing has shown that chemically modified PAC can achieve high levels of Hg removal across SDA–FF combinations in flue gas derived from low-rank fuel. The higher costs associated with these carbons ($6–$7/lb) are offset by the fact that over 90% Hg removal is obtained at approximately 10% of the sorbent addition rate required for similar removals by unmodified commercial PAC. The effort will evaluate similar chemically modified carbons available at lower costs ($1.30–$5/lb). Successful performance by these materials will result in increased cost-effectiveness over previously tested modified and nonmodified ACI sorbents.

EPRI conducted full-scale PAC injection tests at SS10 in April 2002. Results from these tests suggested that the mercury removal effectiveness of untreated PAC was limited. As shown in Figure 4, test results indicated that 70% removal could be achieved across the SDA–FF at an injection concentration of 6.1 lb/Macf. The performance of the iodine-impregnated carbon (IAC) (Type CB IAC) was significantly better. At both 0.7 and 4.0 lb/Macf IAC, ≥96% removal was achieved across the SDA–FF. It is speculated that the spray dryer at SS10 removed a component from the gas, such as HCl, critical to the effective removal of mercury using untreated PAC, but not critical for carbon treated with halides such as iodine.

Full-scale PAC testing conducted at P4 on an ESP unit burning a PRB coal and EERC pilot-scale data with lignite coals (Figure 1) suggest that Hg removals will be low for untreated PAC across the SS1 ESP because of low HCl concentrations. As with the SDA–FF testing,

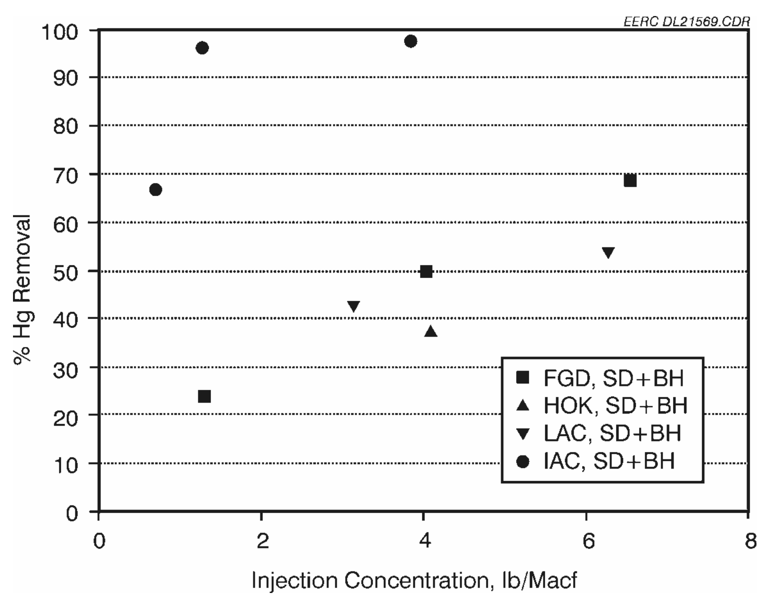

Figure 4. Mercury removal measured across the spray dryer (SD) and baghouse (BH). In the legend, the following activated carbons are called out: a Texas lignite-based carbon from NORIT Americas called DARCO FGD, a German lignite-based carbon from Donau Carbon called DESOREX HOK, a North Dakota lignite-based activated carbon (LAC) from the Illinois State Geological Survey, and a coconut shell-based carbon available from Barnebey Sutcliffe called CB IAC.

treated carbons will be used to overcome this issue for the ESP system at SS1. The recent testing by EPRI will help define the effect of sorbent type and addition rate on mercury removal across the ESP and guide selection of sorbents for longer-term tests, as well as provide appropriate ranges of injection rates to evaluate. Recent EERC testing in summer 2003 further evaluated the use of SEA combined with ACI for lignites to better define the levels required for large-scale testing. This DOE test program will build on the previous testing to evaluate long-term performance of successful sorbents and additives as well as any effects on plant operations.

3.0 EXPERIMENTAL

3.1 Objectives

The goal of this effort is to demonstrate two enhanced sorbent injection technologies at four lignite-fired units to obtain ≥55% Hg removal. This effort will evaluate and demonstrate Hg control via PAC injection at two units using an ESP as the only APCD and two with SDA–FF technology. Since the speciation of Hg in flue gas from lignite is primarily Hg^0 and low reactivity with PAC is an issue, two sorbent enhancement technologies will be tested. The first technology involves SEA that will be tested to evaluate its effect on Hg speciation, PAC effectiveness, and overall Hg removal. The second involves testing of carbons treated prior to injection to greatly improve Hg reactivity and removal for a given injection rate. Supporting objectives are to 1) determine the capital and operating costs for Hg removal with PAC alone, PAC and SEA treated carbon, and SEA alone (for an SDA–FF unit) and 2) determine the balance of plant effects when PAC, SEA, and treated carbons are used for Hg control.

3.2 Planned Scope of Work

The two enhanced PAC technologies for Hg control will be tested at 1) LOS1, an ESP-only unit; 2) SS10, an SDA–FF unit; 3) AVS1, a larger SDA–FF unit; and 4) SS1, another ESP-only unit. Standard PAC enhanced with SEA will be tested at LOS1 and AVS1, while the treated carbons will be tested at SS10 and SS1. Flue gas Hg concentrations will be measured upstream of PAC injection and after the last APCD using continuous mercury monitors (CMMs) and American Society for Testing and Materials Method D6784-02 (Ontario Hydro [OH] method) to evaluate Hg removal rates. In addition, coal and ash samples will be collected and analyzed in order to determine the fate of Hg and its impact on by-products. Parametric tests will determine optimal process conditions for at least 55% Hg removal, and these conditions will be used to test Hg control for long-term evaluation of performance and variability. An economic analysis will be performed using the test data to assess costs for implementing a sorbent-based injection system for Hg control for each of the technologies, plants, and configurations tested.

3.3 Activities to Be Performed

3.3.1 Management

The management team includes the EERC and URS (as a major subcontractor in charge of testing at two of the four sites), with subcontracts to ADA-ES, B&W, and Apogee Scientific.

The subcontractors are providing systems and technology engineering and expertise. Table 2 shows the partners directly involved for each site, as well as the lead management organization for testing activities at each site.

Table 2. Site Management and Partners by Site/Task

Site	Utility Ownership	Lead Organization	Contributing Partners
Task 1 – LOS1	BEPC	EERC	URS, B&W, ADA-ES, EPRI
Task 2 – SS10	GRE	URS	EERC, EPRI, Apogee Scientific
Task 3 – AVS1	BEPC	EERC	URS, B&W, ADA-ES, EPRI
Task 4 – SS1	GRE	URS	EERC, EPRI, Apogee Scientific

The project advisory team, which includes DOE, the Mercury Task Force, NDIC, and EPRI, will provide project direction and review during the course of the project.

3.3.2 Planning and Logistics

Project team members will jointly finalize site-specific test plans for each site/task to include a final test schedule, sampling activities, quality assurance/quality control measures specific to the site, sampling protocols, etc., to meet project objectives. Pretest site visits were held at each site to ensure team readiness regarding equipment installation and testing locations.

3.3.3 Site Preparation

Each host site will make the necessary site preparations to accommodate the PAC/SEA systems and sampling activities, including coordinating addition of ports, constructing safety equipment and sampling shelters, and providing power and sampling access, as required. Team members will coordinate pretest on-site activities with the host sites to ensure that all systems are operational prior to the scheduled testing. Sorbent injection equipment is already in place at Stanton Station. During this reporting period, the sorbent transfer lines between the feeder and the duct were installed.

3.3.4 Sampling Activities

The testing includes 1) baseline sampling to generate Hg removal data with the existing configuration at normal operating conditions, 2) parametric testing to generate data for a range of PAC (and where applicable SEA) or treated carbon injection rates and optimize operational parameters for Hg control, and 3) long-term testing (>1 month) to target Hg reduction of ≥55% using optimal rates established under the parametric tests. Testing activities specific to each site are detailed in the site-specific test plans and will be added in subsequent quarterly reports.

3.3.5 Data Reduction and Analysis

The project will generate voluminous amounts of data, which will be logged carefully so that the effectiveness of SEA/PAC and treated carbons can be accurately assessed relative to both short- and long-term Hg capture/removal. This will provide DOE (and utilities) with a realistic performance value to guide decisions for future installations. Resulting data will be reduced, interpreted, and summarized to determine overall performance and costs. For each site/task, speciated Hg concentrations will be determined for various test conditions and statistically averaged over short- and long-term tests. Then, Hg removal efficiency will be calculated based on inlet coal concentrations as well as on flue gas measurements upstream and downstream of the control technology. Hg concentration and variability in the flue gas will be compared to the Hg content of the coal. Plant operation data will be logged, reduced, and plotted along with Hg concentrations to identify trends and relationships. Results will be summarized for Hg/PAC (and SEA or treated carbons as applicable) impacts on ash. Issues related to unit operation identified during the test program will be documented, as will important design and/or process parameters that appear to limit or impact Hg control.

At the end of the testing program, using data collected during the program, economic analyses will be performed to assess full-scale implementation costs for the SEA/PAC and treated-carbon Hg removal systems for units with either an ESP or SDA–FF. Both capital and operating costs will be determined as a function of Hg removal.

4.0 RESULTS AND DISCUSSIONS

During the current reporting period, testing was completed at Leland Olds Station. Analyses of coal and ash samples from Leland Olds Station were completed. Data reduction has been initiated and is ongoing. In addition, the 1-month test at SS10 began. Preliminary results from both of these tests will be presented at the DOE Review Meeting in July. Field testing at Antelope Valley Station is scheduled to occur in the spring of 2005. Work has begun in developing a draft site-specific test plan. Additionally, communication with plant personnel has been ongoing to prepare for the installation of a pad foundation for the carbon injection system.

5.0 CONCLUSIONS

LOS1 field testing has been completed. Long-term testing was carried out with a PAC rate of 3 lb/Macf and the equivalent of 500 ppm chloride addition to the coal. Initial observations indicate that the target mercury removal rate of 55% was obtained for the test period. Data reduction has been initiated and is ongoing.

SS10 parametric testing was completed, and preliminary data show good removals at treated carbon rates of 1 lb/Macf. One-month testing is ongoing at SS10.

6.0 REFERENCES

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